

**Direct Observation of Morphology of Sand-Clay
Mixtures with Implications for Mechanical Properties in
Sediments**

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Ultrasonic measurements of compressional and shear velocities in dilute sand-clay mixtures demonstrate that small amounts of added clay can dramatically alter wave propagation. The salinity of pore fluid is known to control clay morphology. In order to determine the effect of microstructure and clay morphology on the elastic response, we devised an experiment to directly observe how sand, clay and pore fluid interact on the grain scale. An optical microscope was used to observe relative positions of sand and clay and changes in clay morphology as a function of the chemistry of the pore fluid. We used a pure silica sand with grain sizes between 74-420 microns and a median diameter (d_{50}) of 273 microns, mixed with 1, 3, and 10 weight-% of sodium montmorillonite, a swelling clay. The wetting fluids were deionized water and a 0.1 N CaCl_2 solution.

For the dry sand-clay mixture, we observed that the clay particles would electrostatically cling to the sand grains but do not form a coating. Instead, the clay particles tend to bridge the gaps between grains, influencing how stresses are carried across grain contacts. As expected, due to the chemical interactions between the clay and the water, the clay particles swelled to occupy the available pore space between sand grains when wetted with deionized water. Subsequently, when wetted with CaCl_2 , the clay particles settled and clumped together to form larger clusters or flocs by a process called flocculation. The flocculation process depends mainly on the charge that may be present on the particles in solution. The charge on each particle may repel the other particles and keep the material in suspension, or it may cause the particles to be attracted to each other and form clusters (or flocs). Visual observations confirm that clays in the contact areas between quartz grains can have a large effect on elastic response even in dilute concentrations. These visual observations provide needed insight for analysis of laboratory ultrasonic velocity data using effective medium theories that have appropriate microstructural assumptions. The effect of suspended clay particles on electrical conductivity is also under investigation.

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